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ANALYSIS OF CASCADED H-BRIDGE MULTILEVEL INVERTER WITH LEVEL SHIFTED PWM ON INDUCTION MOTOR

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ABSTRACT

Multi-level converter technology has emerged as a very important alternative in the area of high-power medium voltage energy control. Two level inverters are those which creates a voltage or a current with levels either 0 or ±V dc. To achieve an eminence output voltage or a current waveform with a lowest amount of ripple content, they need high switching frequency. When working at high frequency, high power and high voltage applications these two level inverters have a few restrictions. The multi-level inverter is to produce a quasi sinusoidal voltage from many levels of dc voltages. The obtained output waveform has more steps, which creates a staircase wave form that reaches to a preferred wave form, as the number of levels increases. By the on and off the power switches a sequence of pulses can be produced by using SPWM or sinusoidal pulse width modulation technique which is widely used in power electronics. Sinusoidal pulse width modulation is widely used in many industrial applications and also used for so many years and it is characterized by constant amplitude pulses with dissimilar duty cycle for every period because of its circuit ease and strong control mechanism. To minimize the harmonic content and to control the output voltage of inverter the width of this pulses are modulated. Many PWM techniques are present to regulate the motor, but out of that Sinusoidal pulse width modulation or SPWM is the typically used scheme in motor control and inverter application. Finally a unipolar and bipolar SPWM voltage modulation technique is proposed because this method offers the benefit of successfully doubling the switching frequency of the inverter voltage, thus creating the output filter smaller, economical and trouble free to implement.

KEYWORDS: Cascaded H-Bridge (CHB) Multilevel Inverter (MLI), Total Harmonic Distortion (THD), Pulse Width Modulation (PWM)

INTRODUCTION

An inverter is essential in the power conversion interface to convert the dc power to ac power. Inverters can be generally classified into two types, voltage source and current source inverters. A voltage–fed inverter (VFI) or more commonly a voltage–source inverter (VSI) is one in which the dc source has little or insignificant impedance. The voltage at the input terminals is stable. A current–source inverter (CSI) is connected with adjustable current from the dc source of high impedance that is from a constant dc source. A voltage source inverter uses thyristors as switches, some type of forced commutation is required, while the VSIs made up of using GTOs, power transistors, power MOSFETs or IGBTs, self commutation with base or gate drive signals for their controlled turn-on and turn-off. A typical single-phase voltage or current source inverter can be in the half bridge or full-bridge configuration. The single-phase units can be attached to have three-phase or multiphase topologies. A few industrial applications of inverters are for adjustable-speed ac drives,

induction heating, standby aircraft power supplies, UPS for computers, HVDC transmission lines, etc. The theory of Pulse Width Modulation (PWM) for inverters is described with investigation extended to unusual kinds of PWM strategies. At last the simulation results for a single-phase inverter using the PWM strategies are presented. The schematic diagram of inverter system is as shown in Figure 1, in which the battery or rectifier provides the dc supply to the inverter. The inverter is used to control the fundamental voltage magnitude and the frequency of the ac output voltage. AC loads may need constant or adjustable voltage at their input terminals, when such loads are connected by inverters, it is necessary that the output voltage of the inverters is so regulated as to accomplish the requirement of the loads. For illustration if the inverter supplies power to a magnetic circuit, such as an induction motor, the voltage to frequency ratio at the inverter output terminals must be reserved constant. This avoids saturation in the magnetic circuit of the device fed by the inverter.

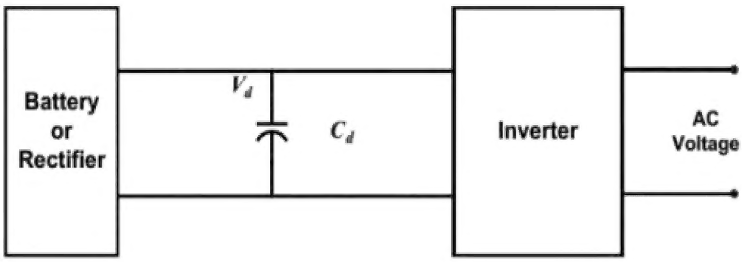

Figure 1: Schematic for Inverter System

HIGH POWER CONVERTERS CLASSIFICATIONS

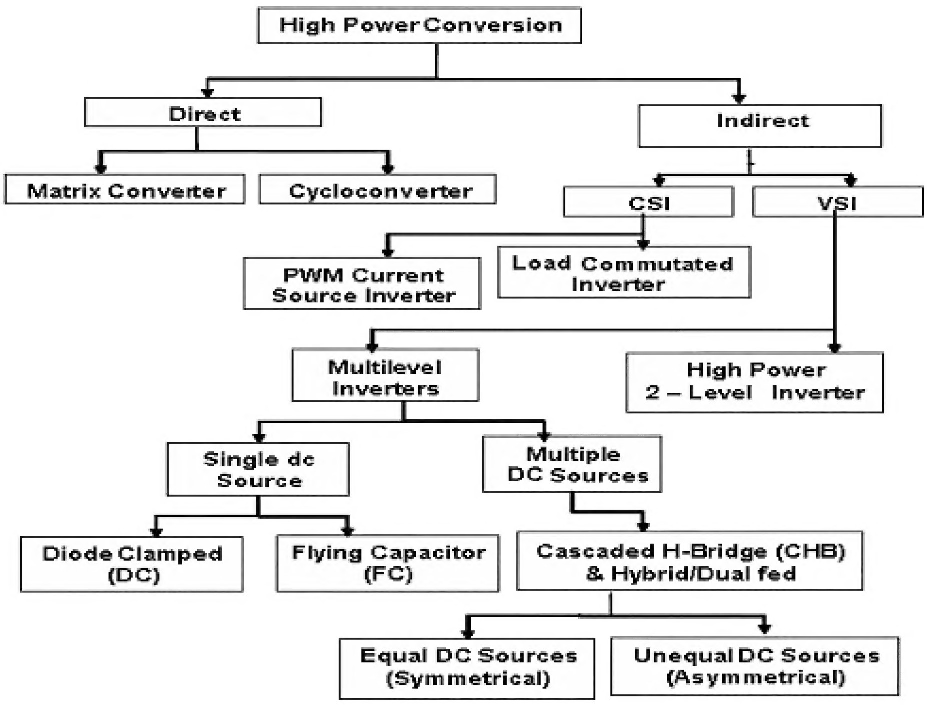

Figure 2: Classification of High Power Converters

Cascaded H-Bridge Multilevel Inverter

The N-level cascaded H-bridge, multilevel inverter comprises½(N-1) series connected single phase H-bridges per

phase, for which each H-bridge has its own isolated dc source. Three output voltages are possible, ±Vs, and zero, giving a total number of states of 3½(N−1), where N is odd. Figure 3 shows one phase of a n-level cascaded H-bridge inverter.

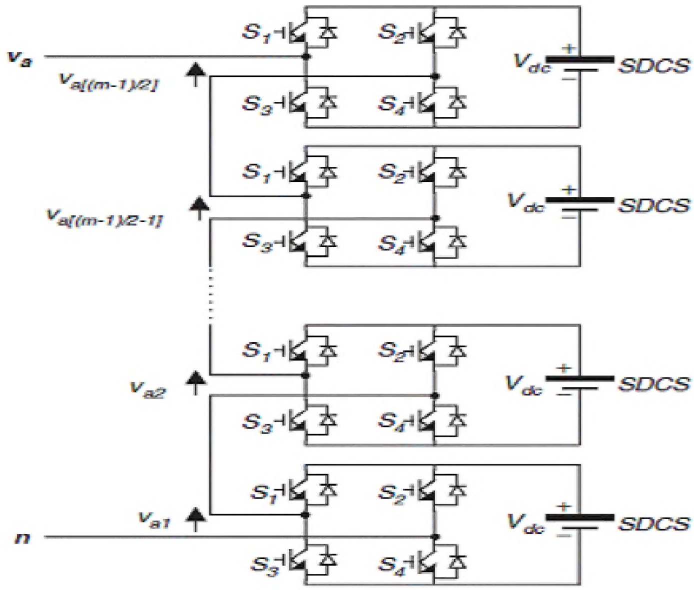

Figure 3: Single-Phase Structure of a Multilevel Cascaded H-Bridge Inverter

The cascaded H-bridge multilevel inverter is based on multiple two level inverter outputs (each H-bridge), with the output of each phase shifted. Despite four diodes and switches, it achieves the greatest number of output voltage levels for the fewest switches. Its main limitation lies in its need for isolated power sources for each level and for each phase, although for VA compensation, capacitors replace the dc supplies, and the necessary capacitor energy is only to replace losses due to inverter losses. Its modular structure of identical H bridges is a positive feature.

- The number of levels in the line-to-line voltage waveform will be k = 2N −1.
- While the number of levels in the line to load neutral of a star (wye) load will be p = 2k −1.
- The number of capacitors or isolated supplies required per phase is Ncap = ½(N −1).
- The number of possible switch states is n states= N phases.
- The number of switches in each leg is Sn = 2(N −1).

Advantages

- The number of possible output voltage levels is more than twice the number of dc sources (m = 2s + 1).
- The series of H-bridges makes for modularized layout and packaging. This will enable the manufacturing process to be done more quickly and cheaply.

Disadvantages

Separate dc sources are required for each of the H-bridges. This will limit its application to products that already have multiple SDCSs readily available.

CASCADED H BRIDGE CONVERTER

Full H-Bridge- Three Level Inverter

Figure 4 shows the Full H-Bridge Configuration. By using single H-Bridge we can get 2 and 3 voltage levels. The number output voltage levels of cascaded Full H-Bridge inverter are given by 2n+1 and voltage step of each level is given by Vdc/n. Where n is number of H-bridges inverter connected in cascaded. The switching table is given in Table I and II.

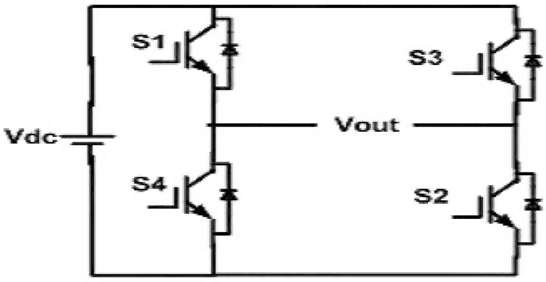

Figure 4: Full H-Bridge Inverter

Table 1: Shows the Switching Table for Full H Bridge for Three Level Inverter

Switches Turn ON	Voltage Level
S1, S2	Vdc/2
S3,S4	-Vdc/2
S2,S4	0

Five Level CHB Inverter

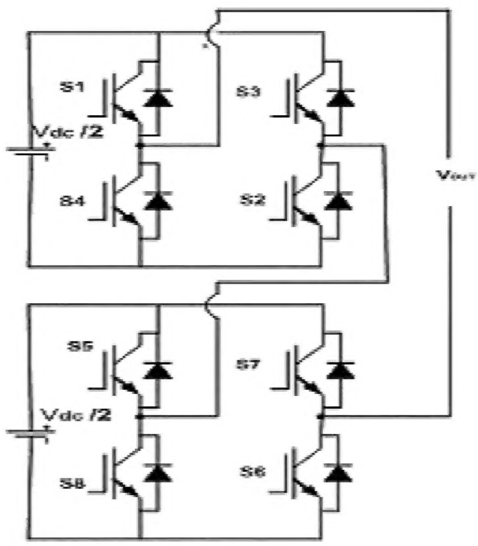

Figure 5: Five Level CHB Inverter

Figure 5 Shows the five level multilevel inverter and Table 2 shows the switching states of the 5 level inverter. Here even though we have eight switches at any switching state only two switches are on/off at a voltage level of Vdc/2, so switching losses are reduced. In three level inverter dv/dt is Vdc, but in five level inverter dv/dt is Vdc/2. As dv/dt reduces the stress on switches reduces and EMI reduces.

Table 2: Switching Table FOR Full H-Bridge of Five Level Inverter

Switches Turn ON	Voltage Level
S1,S2,S6,S8	Vdc/2
S1,S2,S5,S6	Vdc
S2, S4,S6,S8	0
S3,S4,S6,S8	-Vdc/2
S3,S4,S7,S8	-Vdc

Seven Level CHB Inverter

Figure 6 Shows the seven level multilevel inverter and Table 3 shows the switching states of the seven levels CHB inverter.

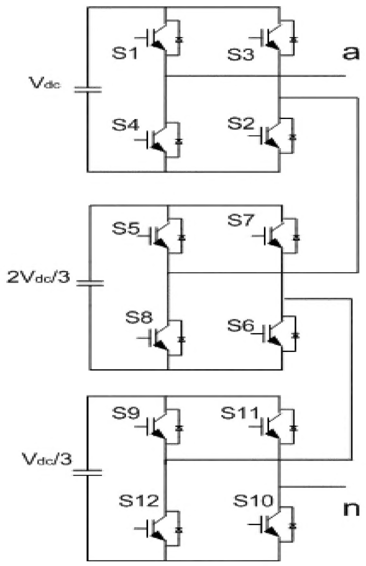

Figure 6: Seven Level CHB Inverter

Table 3: Switching Table for Full H -Bridge of Seven Level Inverter

Switches Turn ON	Voltage Level
S1,S2,S6,S8,S10,S12	Vdc/3
S1,S2,S6,S8,S10,S12	2Vdc/3
S1,S2,S5,S6,S9,S10	Vdc
S2,S4,S6,S8,S10,S12	0
S3,S4,S6,S8 S10,S12	-Vdc/3
S3,S4,S6,S8,S10,S12	-2Vdc/3
S3,S4,S7,S8,S11,S12	-Vdc

SEVERAL MODULATION SCHEMES

Many PWM techniques were developed to control the power inverter gain, and tried to improve the inverter operation, based on minimum harmonic contents in the output voltage. They are quite popular in industrial applications. In that PSPWM and LSPWM methods are merely preferred by many industrial applications.

Phase Shifted Pulse Width Modulation Scheme (PSPWM)

Phase shifted PWM (PS-PWM) is used with cascaded H-bridge (CHB) and flying capacitor (FC) inverters, since each cell is modulated independently using sinusoidal unipolar PWM and bipolar PWM, respectively, providing an even power distribution among the cells. A carrier phase shift of 180^0/m for the CHB and of 360^0/m for the FC is introduced across the cells to generate the stepped multilevel output waveform with lower distortion (where m is the number of cells). The difference between the phase shifts and the type of PWM (unipolar or bipolar) is because one CHB cell generates 3-level outputs, while one FC cell generates two level outputs and also used for many levels as shown in Figure 7.

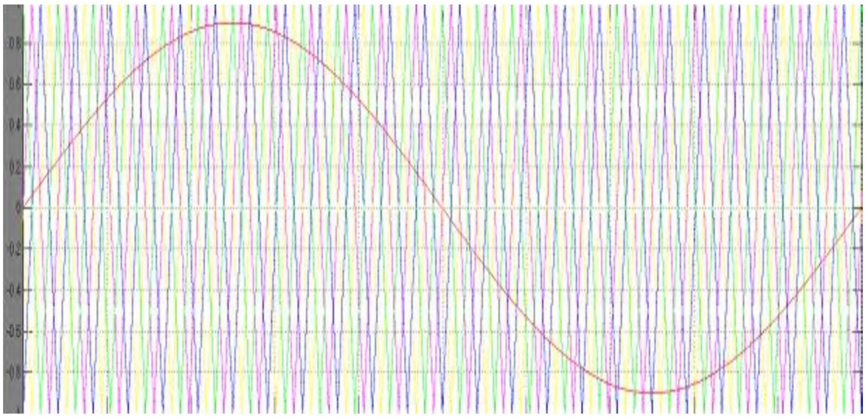

Figure 7: PSPWM Scheme

Level Shifted PWM Scheme (LSPWM)

Level shifted PWM (LS-PWM) is used for controlling voltage of a diode clamped multilevel inverter. The control principle of the level shifted SPWM is to use several triangular carrier signals keeping only one modulating sinusoidal signal. For a three level inverter two carriers and for a five level inverter, four triangular carriers are needed. In general if an m-level inverter is employed, (m-1) carriers are needed. The carriers have the same frequency f_c and the same peak-to-peak amplitude A_C. The zero reference is placed in the middle of the carrier set. The modulating signal is a sinusoid of frequency f_m and amplitude A_m. At every instant, each carrier is compared with the modulating signal. Each comparison switches the switch "on" if the modulating signal is greater than the triangular carrier assigned to that switch.

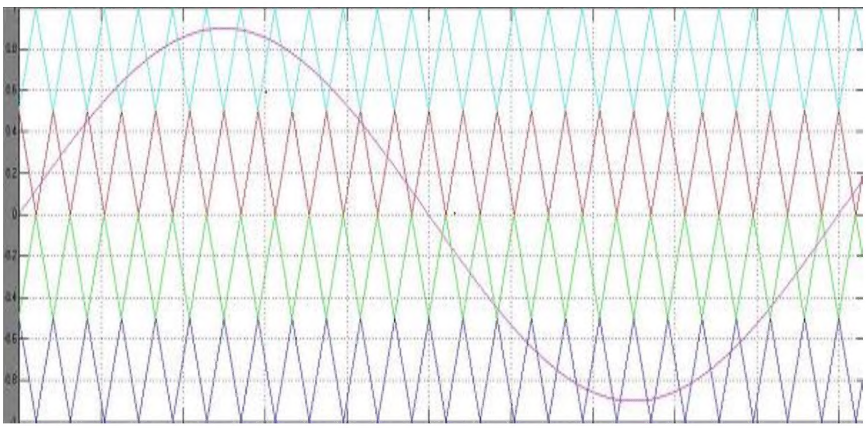

Figure 8: LSPWM Scheme

INDUCTION MOTOR

An induction motor is found more advantageous because of its simple construction, reliability, roughness and little cost, so that it is widely used in many industrial applications. In addition, in distinguish to the commutation Dc motor, it can be used in destructive or unstable environments since there are no problems with spark and corrosion. These advantages, however, are engaged by control problems when using induction motor in speed regulated industrial drives. Speed control (v/f control) of induction motor requires two stage conversion (ac-dc and dc-ac), but most of the classical inverters gives poor performance. Here a Reversing Voltage topology in five level and seven level inverter is implemented for induction motor load which has superior characteristics over traditional topologies in terms of required components as switches, voltage balancing, control requirements and reliability. Here SPWM controller has less complexity.

Dynamic Modeling of Induction Motor

In a predictable four pole induction motor, there are two sets of similar voltage profile windings will be there in the total phase winding. The series connections of two windings are shown in figure 9 (a). For the projected inverter these two equal voltage profile winding coils are detached, and the accessible four terminals are taken out, like shown in the figure 9 (b). Since these two windings are divided equally, stator resistance, Stator leakage inductance and the magnetizing inductance of each similar voltage profile windings are the same to the half of the normal induction motor shown in figure 9 (a). The voltage equitation for the stator winding is specified by common dc link.

$$V_{a1} - V_{a2} = \left(\frac{r_s}{2}\right) * i_{as} + \left(\frac{L_{ss}}{2}\right) * i_{as} - \left(\frac{1}{2}\right) * \left(\frac{L_m}{2}\right) * i_{bs} - \left(\frac{1}{2}\right) * \left(\frac{L_m}{2}\right) * i_{cs} \quad (1)$$

$$V_{a3} - V_{a4} = \left(\frac{r_s}{2}\right) * i_{as} + \left(\frac{L_{ss}}{2}\right) * i_{as} - \left(\frac{1}{2}\right) * \left(\frac{L_m}{2}\right) * i_{bs} - \left(\frac{1}{2}\right) * \left(\frac{L_m}{2}\right) * i_{cs} \quad (2)$$

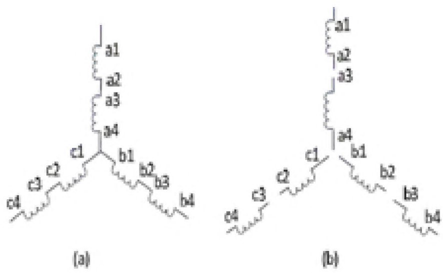

Figure 9: Induction Motor Stator Winding: (a) General Arrangement (b) Arrangement for the Proposed Inverter

The effective voltage across the stator winding is the sum of the voltages across the two individual windings.

$$V_{as} = (V_{a1} - V_{a2}) + (V_{a3} - V_{a4}) \quad (3)$$

The motor phase voltage can be achieved by substituting equations (1) and (2) in (3)

$$V_{as} = r_s * L_{ss} + i_{as} * - \left(\frac{1}{2}\right) * L_m * i_{bs} - \left(\frac{1}{2}\right) * L_m * i_{cs} \quad (4)$$

Similarly voltage equitation for the remaining phases is

$$V_{bs} = r_s * i_{bs} + L_{ss} * i_{bs} - \left(\frac{1}{2}\right) * L_m * i_{as} - \left(\frac{1}{2}\right) * L_m * i_{cs} \quad (5)$$

$$V_{cs} = r_s * i_{cs} + L_{ss} * i_{cs} - \left(\frac{1}{2}\right) * L_m * i_{as} - \left(\frac{1}{2}\right) * L_m * i_{bs} \tag{6}$$

Voltage equations in dq0 frame can be solved from the basic equations of induction motor.

$$V_{qs} = r_s * i_{qs} + \omega * \lambda_{ds} + \rho * \lambda_{qs} \tag{7}$$

$$V_{ds} = r_s * i_{ds} - \omega * \lambda_{qs} + \rho * \lambda_{ds} \tag{8}$$

$$V_{0s} = r_s * i_{0s} + \rho * \lambda_{0s} \tag{9}$$

$$V_{qr} = r_r * i_{qr} + (\omega - \omega_r) * \lambda_{dr} + \rho * \lambda_{qr} \tag{10}$$

$$V_{dr} = r_r * i_{dr} - (\omega - \omega_r) * \lambda_{qr} + \rho * \lambda_{dr} \tag{11}$$

$$V_{0r} = r_r * i_{0r} + \rho * \lambda_{0r} \tag{12}$$

Flux linkages are as follows

$$\lambda_{qs} = L_{ss} * i_{qs} + L_M * i_{qr} \tag{13}$$

$$\lambda_{ds} = L_{ss} * i_{ds} + L_M * i_{dr} \tag{14}$$

$$\lambda_{0s} = L_{1s} * i_{0s} \tag{15}$$

$$\lambda_{qr} = L_{rr} * i_{qr} + L_M * i_{qs} \tag{16}$$

$$\lambda_{dr} = L_{rr} * i_{dr} + L_M * i_{ds} \tag{17}$$

$$\lambda_{0r} = L_{1r} * i_{0r} \tag{18}$$

The expression for the electromagnetic torque in terms of dq0 axis currents is

$$T_e = \left(\frac{3}{2}\right) * \left(\frac{P}{2}\right) * L_M * (i_{qs} * i_{dr} + i_{ds} * i_{qr}) \tag{19}$$

Rotor speed in terms of Torque is

$$\frac{d}{dt}\omega_e = \left(\frac{P}{2*J}\right) * (T_e - T_L) \tag{20}$$

Where

d: direct axis,

q: quadrature axis,

s: stator variable,

r: rotor variable,

V_{ds},V_{qs},: q and d–axis stator voltages,

V_{dr},V_{qr},: q and d–axis rotor voltages,

r_r : Rotor resistance,

Vr_s : Stator resistance,

L1s: stator leakage inductance,

L1r: rotor leakage inductance,

IQS, ids: q and d–axis stator currents,

iqr, idr: q and d–axis rotor currents,

P: number of poles,

J: moment of inertia,

Te: electrical output torque,

TL: load torque.

From the equations (1), (2),(2) it can be observed that there is no difference between the normal induction motor shown in figure 9 (a) and the disconnected (Identical voltage profile windings) motor shown in figure 9 (b)

MATLAB/SIMULINK RESULTS

Three-Level

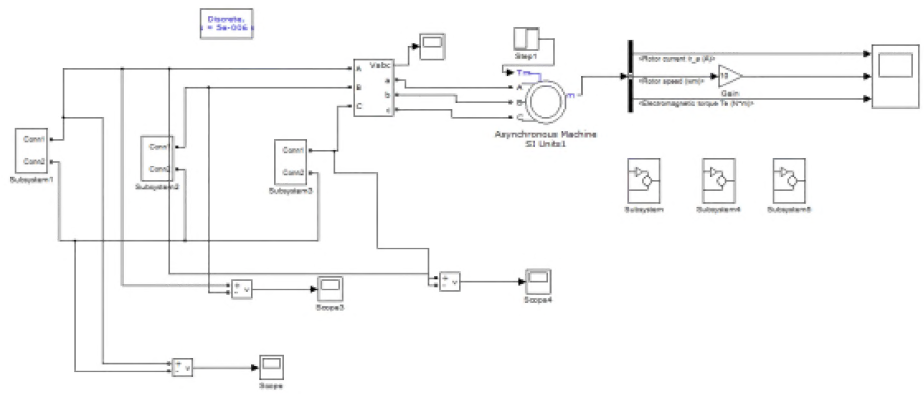

Figure 10: Matlab/Simulink Model of Three Phase Three Level PWM Inverter Fed Induction Motor

Figure 10 shows the Matlab/Simulink model of three phase three level PWM inverter fed induction motor.

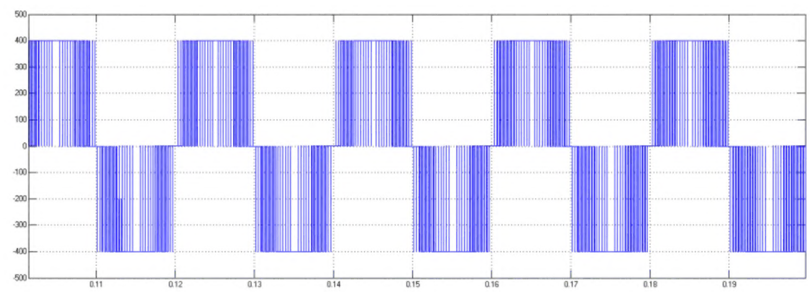

Figure 11: Line Voltage of the Three Level PWM Inverter Fed Induction Motor

Figure 11 Shows line Voltage of the Three Level PWM Inverter Fed Induction Motor.

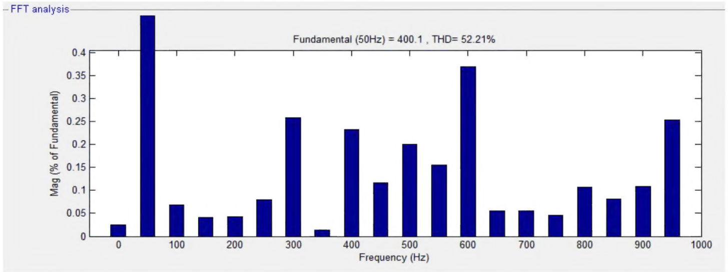

Figure 12: Spectrum Analysis of Line Voltage of Three Levels H-Bridge Inverter with Sinusoidal PWM

Figure 12 shows FFT analysis of line voltage of three levels H-Bridge inverter with sinusoidal PWM.

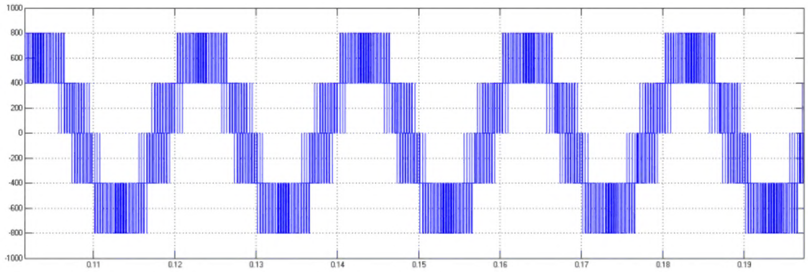

Figure 13: Phase Voltage of Three Level PWM Inverter Fed Induction Motor

Figure 13 Shows The Phase To Phase Voltage Of Three Level PWM Inverter Fed Induction Motor.

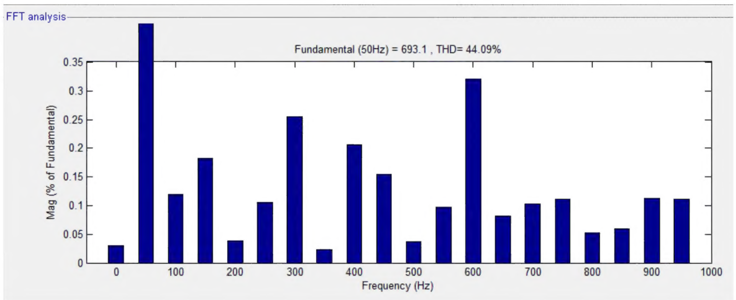

Figure 14: Spectrum Analysis of Phase Voltage of Three Levels H-Bridge Inverter with Sinusoidal PWM

Figure 14 shows FFT analysis of phase voltage of three levels H-Bridge inverter with sinusoidal PWM.

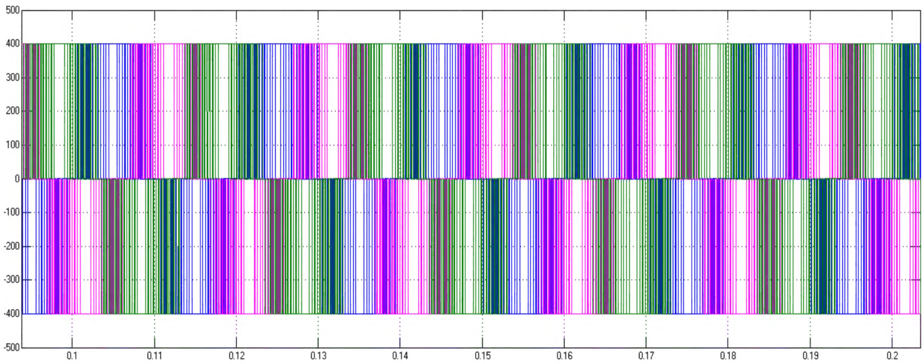

Figure 15: Phase Voltage of Three Phase Three Level PWM Inverter Fed Induction Motor

Figure 15 shows the phase voltage of three phase three level PWM inverter fed induction motor.

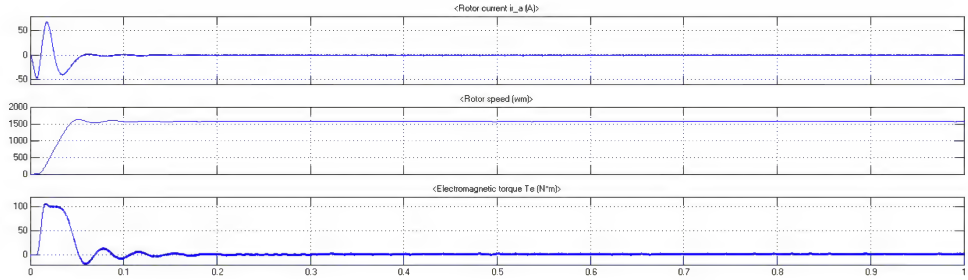

Figure 16: The Generated Current, Torque AND Output Speed of the Three Phase Three Level Fed Induction Motor Level Shifted Carrier PWM

The behavior of the generated electromagnetic torque is also of vital importance. Figure 16 shows the generated current, torque and output speed of the level shifted carrier PWM three phase three level fed induction motor

FIVE LEVEL

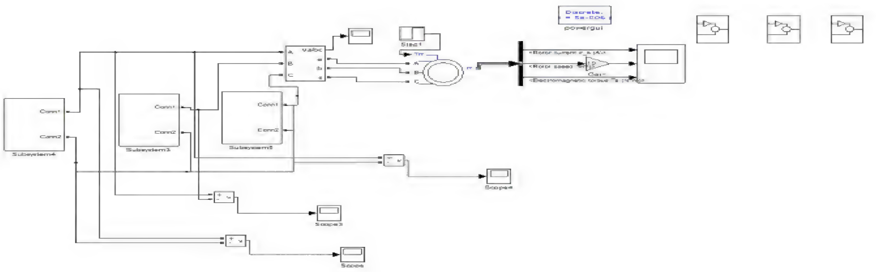

Figure 17: Matlab/Simulink Model of Three Phase Five Level PWM Inverter Fed Induction Motor

Figure 17 shows the Matlab/Simulink model of three phase five level PWM inverter fed induction motor.

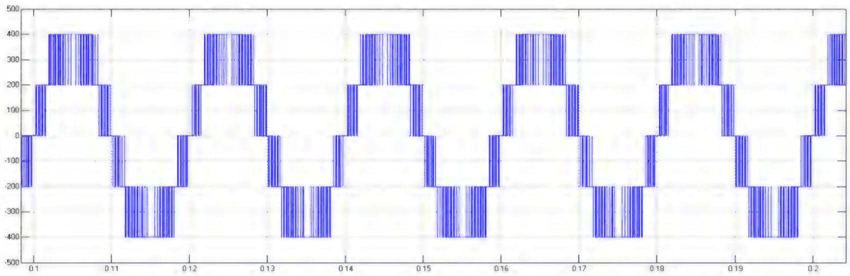

Figure 18: Line Voltage of the Five Level PWM Inverter Fed Induction Motor

Figure 18 Shows line Voltage of the five Level PWM Inverter Fed Induction Motor.

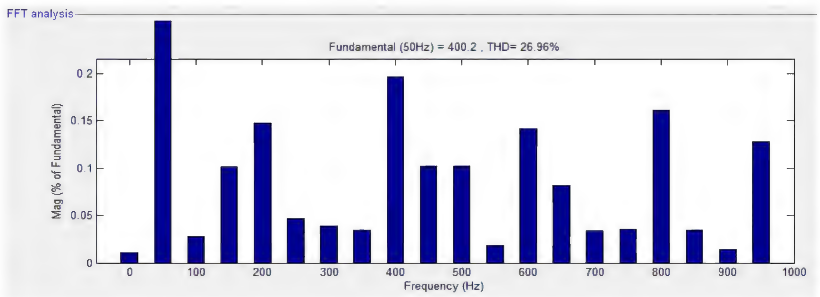

Figure 19: Spectrum Analysis of Line Voltage of Five Levels H-Bridge Inverter with Sinusoidal PWM

Figure 19 shows FFT analysis of line voltage of five levels H-Bridge inverter with sinusoidal PWM.

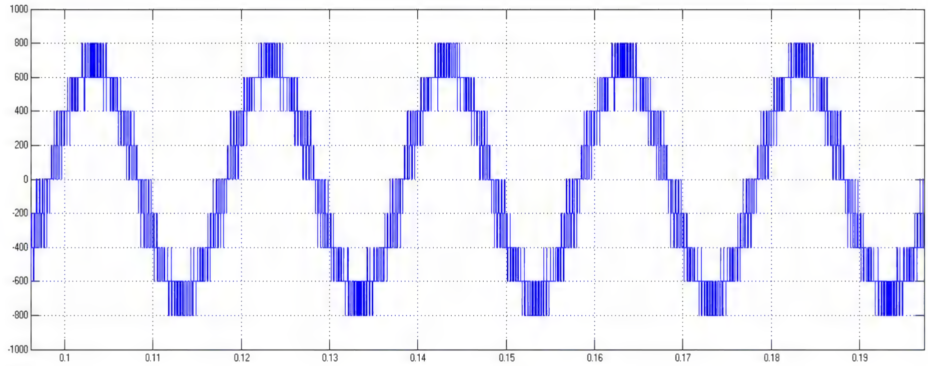

Figure 20: Phase Voltage of Five Level PWM Inverter Fed Induction Motor

Figure 20 Shows the Phase Voltage of five Level PWM Inverter Fed Induction Motor.

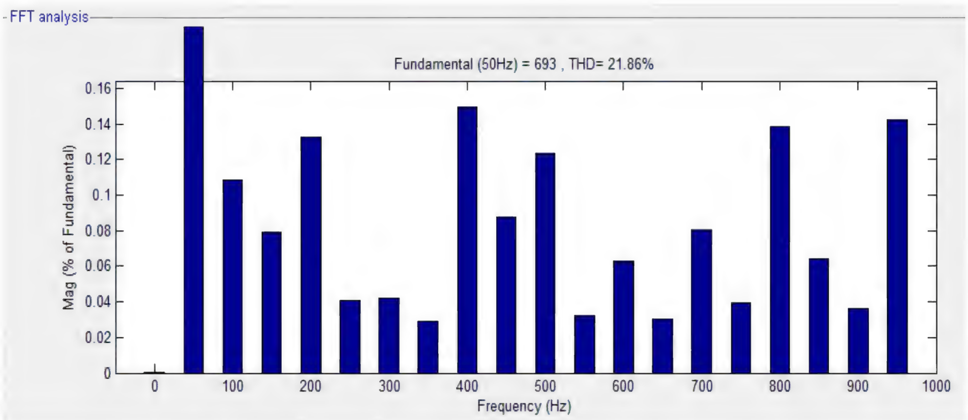

Figure 21: Spectrum Analysis of Phase Voltage of Five Levels H-Bridge Inverter with Sinusoidal PWM

Figure 21 shows FFT analysis of phase to phase voltage of five levels H-Bridge inverter with sinusoidal PWM.

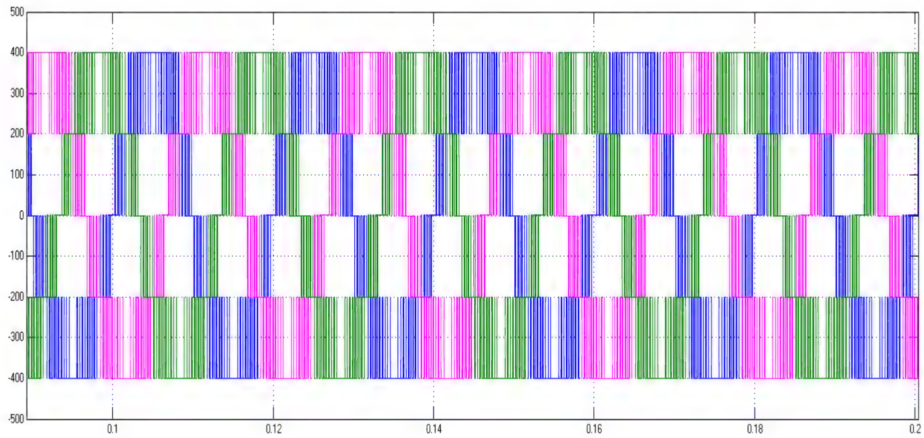

Figure 22: Phase Voltage of Three Phase Five Level PWM Inverter Fed Induction Motor

Figure 22 shows the phase voltage of three phase five level PWM inverter fed induction motor.

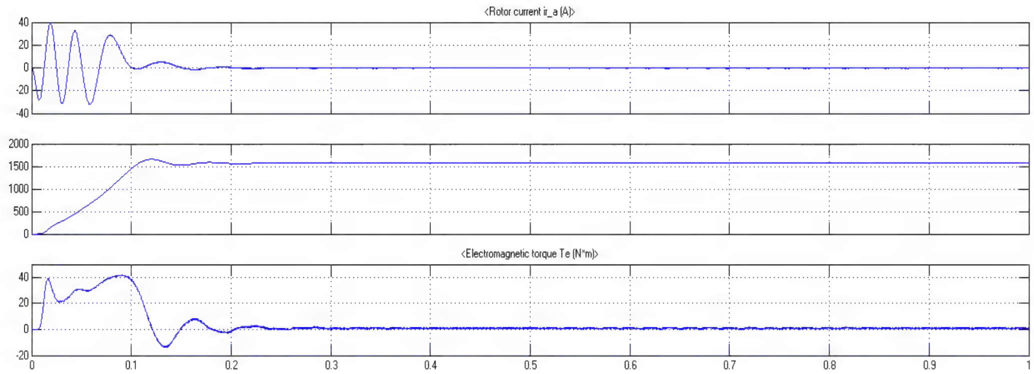

Figure 23: The Generated Current, Torque and Output Speed of the Three Phase Five Level CHB Inverter Fed Induction Motor Level Shifted Carrier PWM

The behavior of the generated electromagnetic torque is also of vital importance. Fig.23 shows the generated current, torque and output speed of the level shifted carrier PWM three phase five level CHB inverter fed induction motor.

7-LEVEL LSC PWM

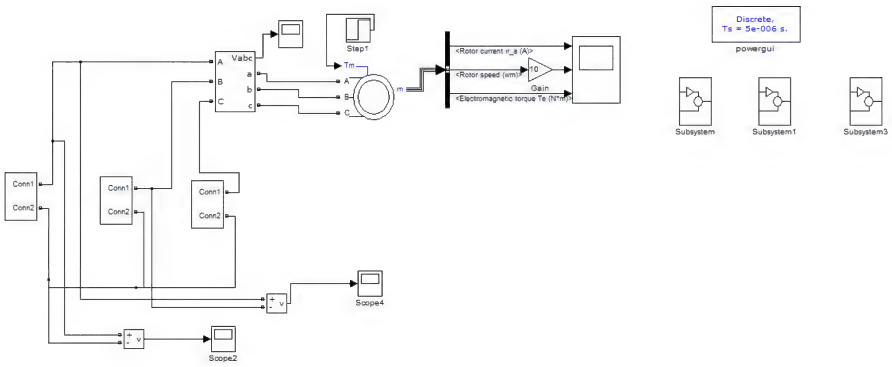

Figure 24: Matlab/Simulink Model of Three Phase Seven Level PWM Inverter Fed Induction Motor

Figure 24 shows the Matlab/Simulink model of three phase seven level PWM inverter fed induction motor.

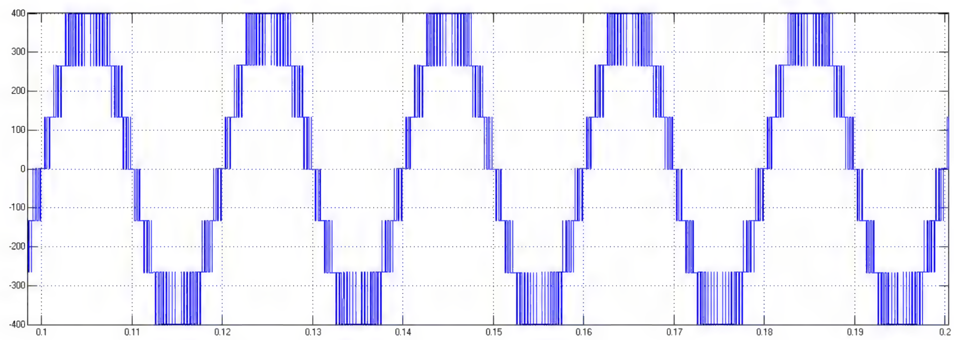

Figure 25: Line Voltage of the Seven Level PWM Inverter Fed Induction Motor

Figure 25 Shows line Voltage of the seven Level PWM Inverter Fed Induction Motor.

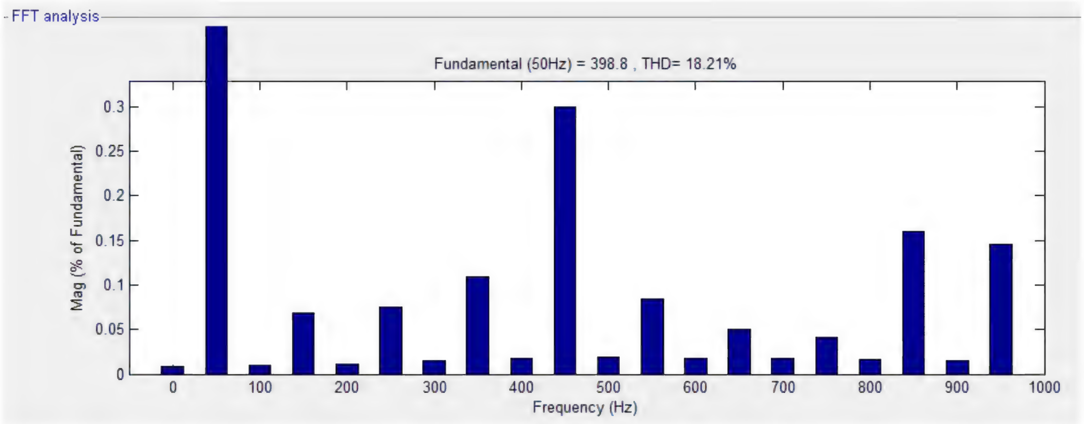

Figure 26: Spectrum Analysis of Line Voltage of Seven Levels H-Bridge Inverter with Sinusoidal PWM

Figure 26 shows FFT analysis of line voltage of seven levels H-Bridge inverter with sinusoidal PWM.

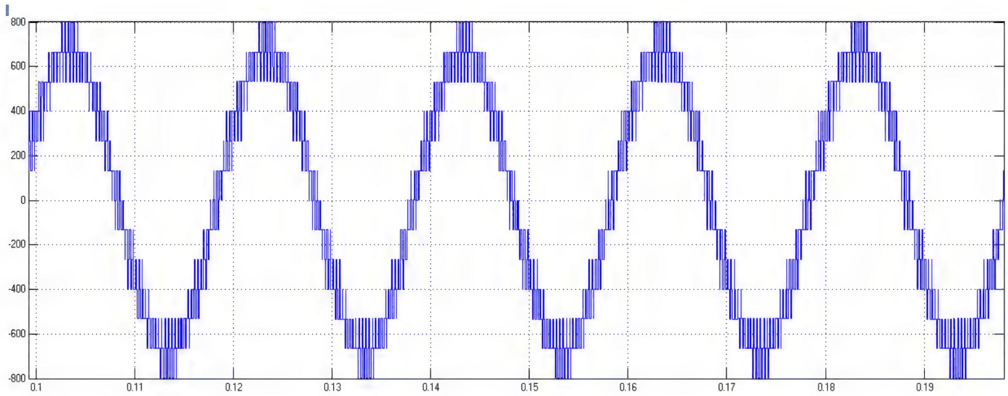

Figure 27: Phase Voltage of Seven Level PWM Inverter Fed Induction Motor

Figure 27 Shows the Phase Voltage of seven Level PWM Inverter Fed Induction Motor.

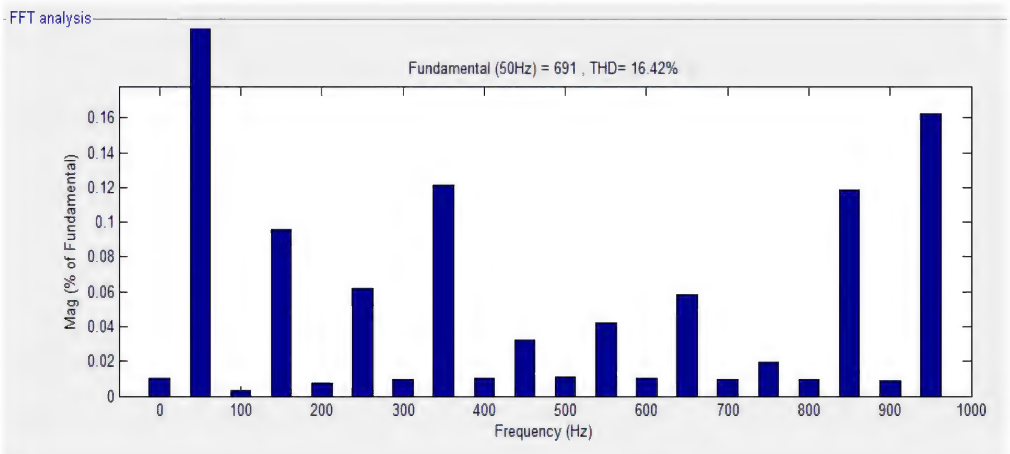

Figure 28: Spectrum Analysis of Phase Voltage of Seven Levels H-Bridge Inverter with Sinusoidal PWM

Figure 28 shows FFT analysis of phase to phase voltage of seven levels H-Bridge inverter with sinusoidal PWM.

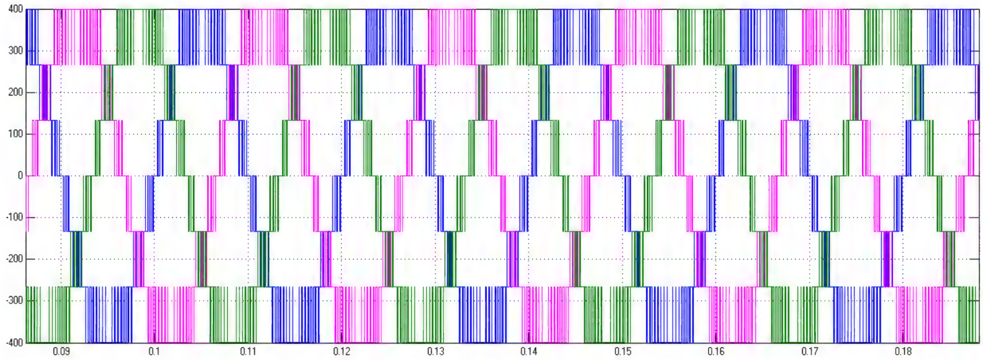

Figure 29: Phase Voltage of Three Phase Seven Level PWM Inverter Fed Induction Motor

Figure 29 shows the phase voltage of three phase seven level PWM inverter fed induction motor.

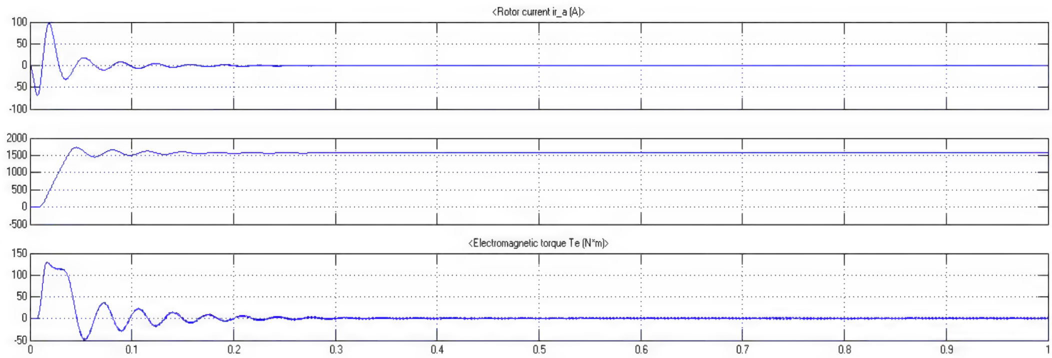

Figure 30: The Generated Current, Torque and Output Speed of the Three Phase Seven Level Fed Induction Motor Level Shifted Carrier PWM

The behavior of the generated electromagnetic torque is also of vital importance. Fig.30 shows the generated current, torque and output speed of the level shifted carrier PWM three phase seven level fed induction motor.

NINE LEVEL

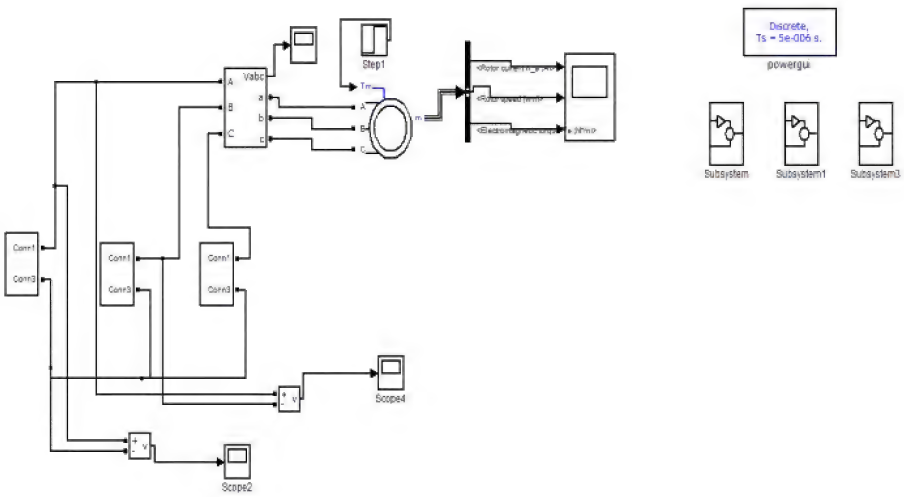

Figure 31: Matlab/Simulink Model of Three Phase Nine Level PWM Inverter Fed Induction Motor

Figure 31 shows the Matlab/Simulink model of three phase nine level PWM inverter fed induction motor.

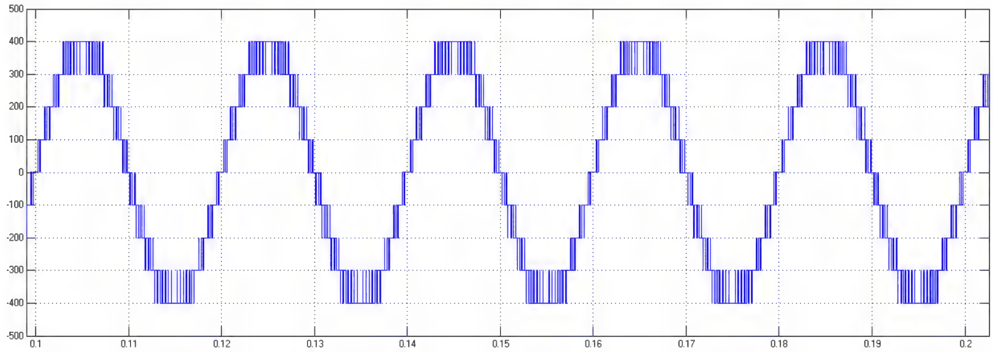

Figure 32: Line Voltage of the Nine Level PWM Inverter Fed Induction Motor

Figure 32 Shows line Voltage of the nine Level PWM Inverter Fed Induction Motor.

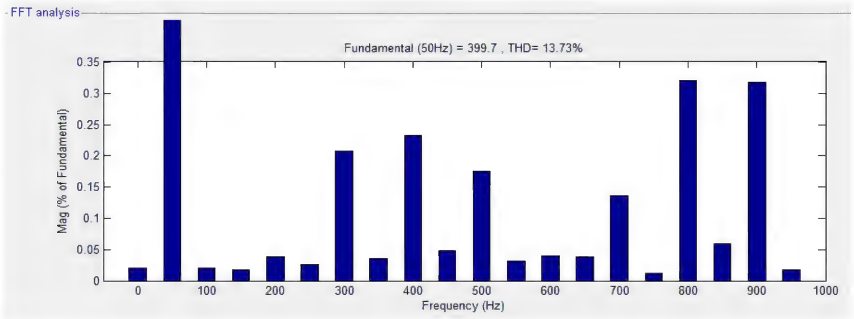

Figure 33: Spectrum Analysis of Line Voltage of Nine Levels H-Bridge Inverter with Sinusoidal PWM

Figure 33 shows FFT analysis of line voltage of nine levels H-Bridge inverter with sinusoidal PWM.

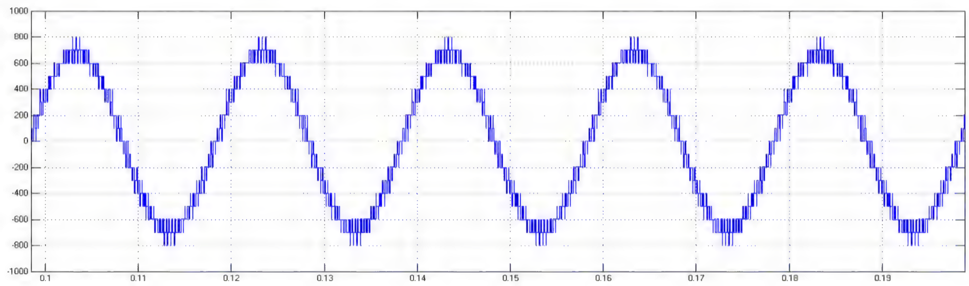

Figure 34: Phase Voltage of Nine Level PWM Inverter Fed Induction Motor

Figure 34 Shows the Phase to Phase Voltage of nine Level PWM Inverter Fed Induction Motor.

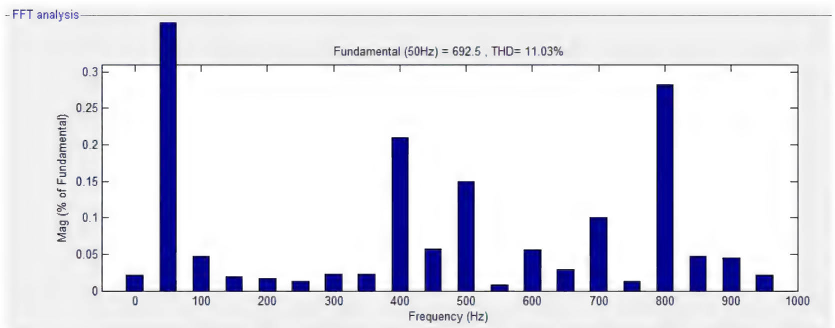

Figure 35: Spectrum Analysis of Phase to Phase Voltage of Nine Levels H-Bridge Inverter with Sinusoidal PWM

Figure 35 shows FFT analysis of phase to phase voltage of nine levels H-Bridge inverter with sinusoidal PWM.

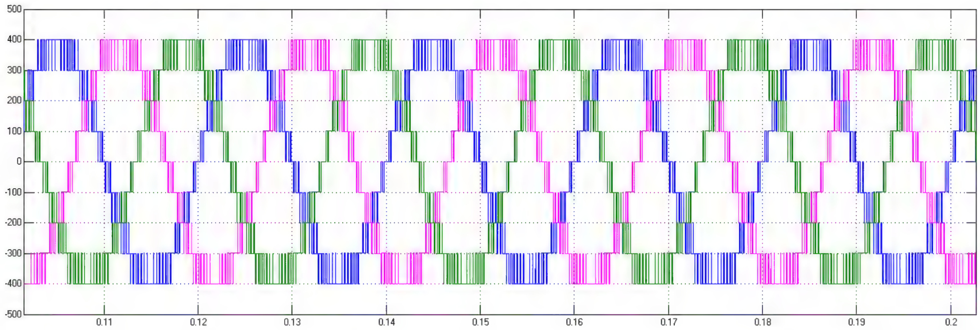

Figure 36: Phase to Phase Voltage of Three Phase Nine Level PWM Inverter Fed Induction Motor

Figure 36 shows the phase to phase voltage of three phase nine level PWM inverter fed induction motor.

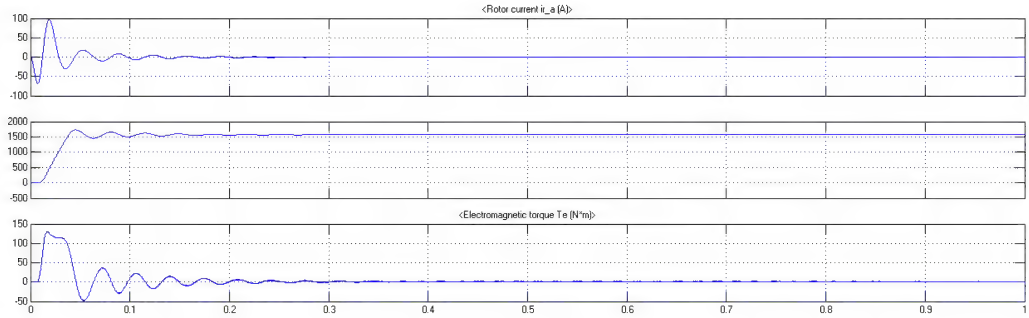

Figure 37: The Generated Current, Torque and Output Speed of the Three Phase Nine Level Fed Induction Motor Level Shifted Carrier PWM

The behavior of the generated electromagnetic torque is also of vital importance. Figure 37 shows the generated current, torque and output speed of the level shifted carrier PWM three phase nine level fed induction motor.

Eleven level

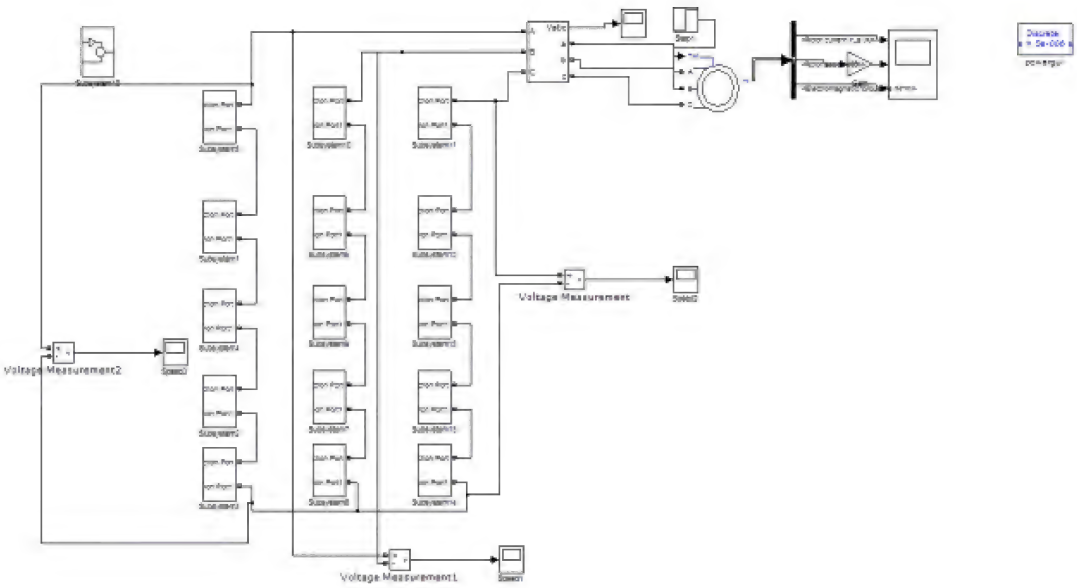

Figure 38: Matlab/Simulink Model of Three Phase Eleven Level PWM Inverter Fed Induction Motor

Figure 38 shows the Matlab/Simulink model of three phase eleven level PWM inverter fed induction motor.

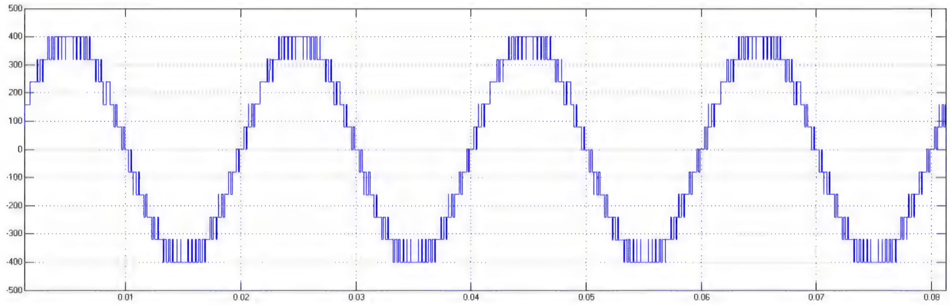

Figure 39: Line Voltage of the Eleven Level PWM Inverter Fed Induction Motor

Figure 39 Shows Single Bridge Voltage o the eleven Level PWM Inverter Fed Induction Motor.

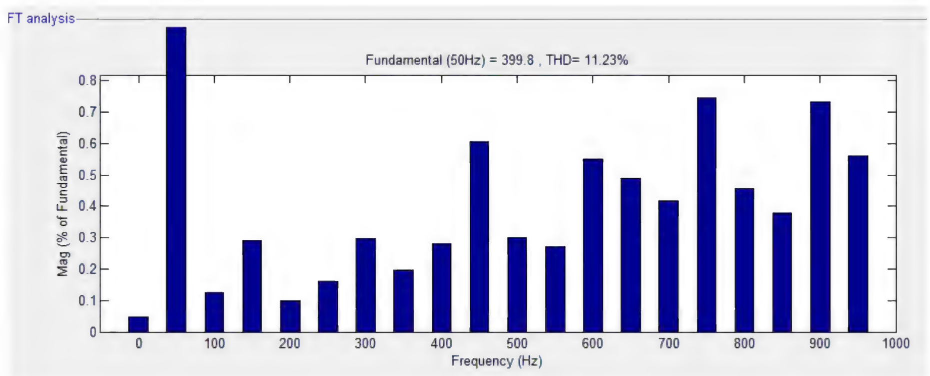

Figure 40: Spectrum Analysis of Line Voltage of Eleven Levels H-Bridge Inverter with Sinusoidal PWM

Figure 40 shows FFT analysis of single bridge voltage of eleven levels H-Bridge inverter with sinusoidal PWM.

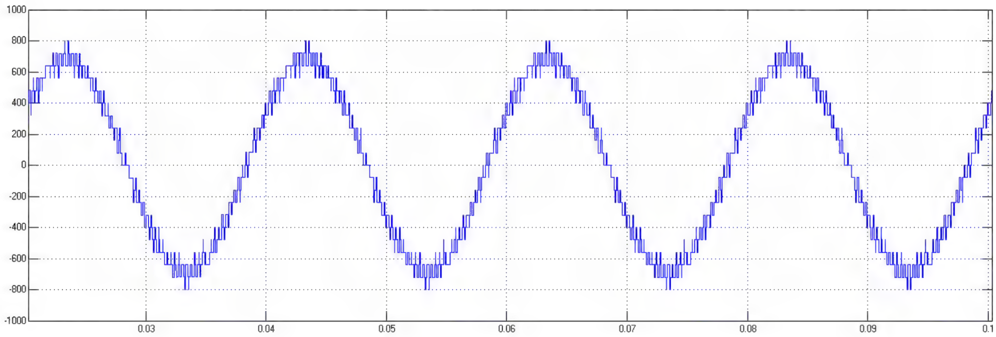

Figure 41: Phase Voltage of Eleven Level PWM Inverter Fed Induction Motor

Figure 41 Shows the Phase to Phase Voltage of eleven Level PWM Inverter Fed Induction Motor.

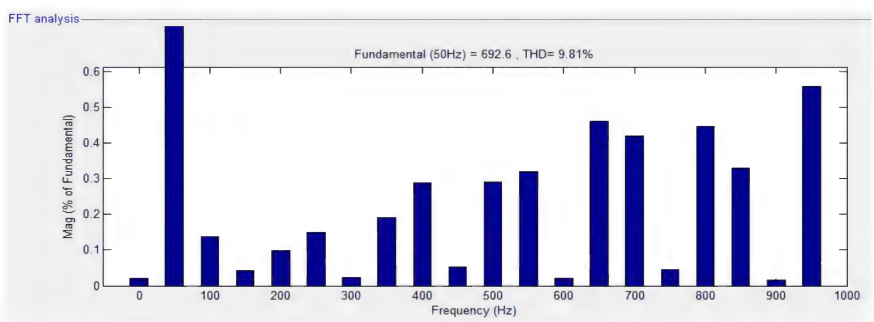

Figure 42: Spectrum Analysis of Phase Voltage of Eleven Levels H-Bridge Inverter with Sinusoidal PWM

Figure 42 shows FFT analysis of phase voltage of eleven levels H-Bridge inverter with sinusoidal PWM.

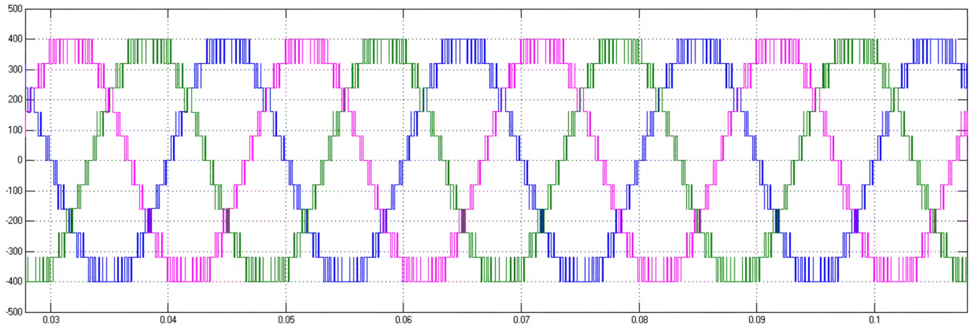

Figure 43: Phase to Phase Voltage of Three Phase Eleven Level PWM Inverter Fed Induction Motor

Figure 43 shows the phase to phase voltage of three phase eleven level PWM inverter fed induction motor.

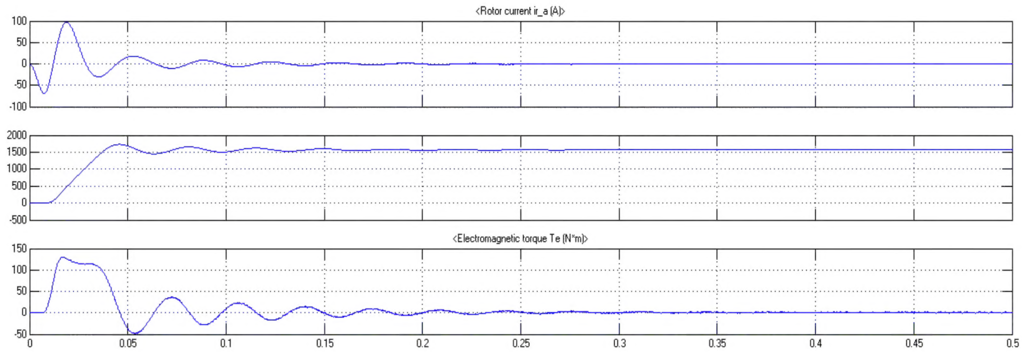

Figure 44: The Generated Current, Torque and Output Speed of the Three Phase Eleven Level Fed Induction Motor Level Shifted Carrier PWM

The behavior of the generated electromagnetic torque is also of vital importance. Fig.44 shows the generated current, torque and output speed of the level shifted carrier PWM three phase eleven level fed induction motor.

Table 4: Comparison of Line Voltage THD and Phase Voltage THD

Levels	dv/dt	Line Voltage THD%	Phase Voltage THD%
3-level	Vdc	52.21	44.09
5-level	Vdc/2	26.96	21.86
7-level	Vdc/3	18.21	16.42
9-level	Vdc/4	13.73	11.03
11-level	Vdc/5	11.23	9.81

CONCLUSIONS

This paper has provided a brief summary of multilevel inverter circuit topologies (3-level, 5-level, 7-level, 9-level, and 11-level) and their analysis with respect to induction motor drives. Each MLI has its own mixture of advantages and disadvantages and for any one particular application, one topology will be more appropriate than the others. Often, topologies are chosen based on what has gone before, even if that topology may not be the best choice for the application. The advantages of the body of research and familiarity within the engineering community may outweigh other technical disadvantages. Multilevel converters can achieve an effective increase in overall switch frequency through the cancellation

of the lowest order switch frequency terms. There are many modulation techniques for multi level inverters. But carrier based modulation technique is easy and efficient. The PWM output spectra were calculated from basic operation simulated using MATLAB.

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